SCINTILLATOR PANEL, RADIATION IMAGE SENSOR, AND METHODS OF MAKING THE SAME

RELATED APPLICATIONS

This is a Continuation-In-Part application of International Patent Application serial No. PCT/JP99/03264 filed on Jun. 18, 1999 now pending.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a scintillator panel and a radiation image sensor which are used for medical X-ray photography and the like, and methods of making them.

2. Related Background Art

While X-ray sensitive films have been used in medical and industrial X-ray photography, radiation imaging systems using radiation detectors have been coming into wider use from the viewpoint of convenience and their storability of photographed results. In such a radiation imaging system, pixel data caused by two-dimensional radiation are acquired by a radiation detector as an electric signal, which is then processed by a processing unit, so as to be displayed onto a monitor.

Conventionally known as a typical radiation detector is one disclosed in WO 92/06476 or the like. In this radiation detector, a scintillator directly formed on a substrate and an imaging device are bonded together, such that the radiation incident from the substrate side is converted into visible light by the scintillator, so as to be detected.

On the other hand, Japanese Patent Application Laid-Open No. HEI 5-196742 and No. SHO 63-215987 disclose a radiation detector in which, in order to protect a scintillator formed on an imaging device or a fiber optical plate (FOP), i.e., an optical part constituted by a plurality of fibers bundled together, against vapor (moisture) in the air, a water-impermeable, moisture-resistant barrier is formed on the upper side of scintillator layer.

SUMMARY OF THE INVENTION

In the case where the scintillator is directly formed on the substrate as in the radiation detectors mentioned above, however, the state of substrate surface (such as unevenness, roughness, and streaks formed upon rolling) has greatly influenced characteristics of scintillator panels. Namely, optical mirror surfaces are hard to prepare in Al sheets, Be sheets, and the like which are used as substrates. Therefore, in the case where radiation is made incident from the substrate side and is converted by the scintillator into visible light, from which an image is subsequently acquired through lens coupling and the like, image quality, luminance, resolution, and the like have greatly been influenced by the state of substrate surface.

It is an object of the present invention to provide a scintillator panel, a radiation image sensor, and methods of making them, which would not be influenced by the state of substrate surface.

The scintillator panel of the present invention comprises a radiation-transparent substrate, a flat resin film formed on the substrate, a reflecting film formed on the flat resin film, and a scintillator formed on the reflecting film.

According to the scintillator panel of the present invention, since the scintillator is provided on the flat resin film formed on the substrate, characteristics of the scintillator panel can be kept from changing due to the state of substrate surface. Also, the scintillator plate can enhance its optical output since it has a reflecting film.

The scintillator panel of the present invention is characterized in that at least a part of the scintillator of scintillator panel is covered with a transparent organic film. Since the scintillator is covered with the organic film, the scintillator panel of the present invention can protect the scintillator against vapor (moisture).

The radiation image sensor of the present invention comprises a radiation-transparent substrate, a flat resin film formed on the substrate, a reflecting film formed on the flat resin film, a scintillator formed on the reflecting film, and an imaging device disposed so as to face the scintillator. According to the radiation image sensor of the present invention, since the scintillator is provided on the flat resin film formed on the substrate, characteristics of the scintillator panel comprising the radiation image sensor can be kept from changing due to the state of substrate surface. Also, the scintillator plate can enhance its optical output since the reflecting film is provided.

The radiation image sensor of the present invention is characterized in that at least a part of the scintillator of radiation image sensor is covered with a transparent organic film. According to the scintillator of the present invention, since the scintillator is covered with the organic film, the scintillator can be protected against vapor (moisture).

The method of making a scintillator panel in accordance with the present invention comprises steps of forming a flat resin film on a radiation-transparent substrate, forming a reflecting film on the flat resin film, and forming a scintillator on the reflecting film.

In the method of making a scintillator panel in accordance with the present invention, the flat resin film is formed on the substrate, and the scintillator is formed on the flat resin film, whereby a scintillator panel whose characteristics would not change due to the state of substrate surface can be made. Also, since the reflecting film is formed on the flat resin film, the optical output of scintillator plate can be enhanced.

The method of making a scintillator panel in accordance with the present invention may further comprise a step of covering at least a part of the scintillator with a transparent organic film. Since the scintillator is covered with the organic film, the present invention can make a scintillator panel which can protect the scintillator against vapor (moisture).

The method of making a radiation image sensor of the present invention comprises steps of forming a flat resin film on a radiation-transparent substrate, forming a reflecting film on the flat resin film, forming a scintillator on the reflecting film, and disposing an imaging device opposite the scintillator.

In the method of making a radiation image sensor in accordance with the present invention, the flat resin film is formed on the substrate, and the scintillator is formed on the flat resin film, whereby a radiation image sensor comprising a scintillator panel whose characteristics would not change due to the state of substrate surface can be made. Also, since the reflecting film is formed on the flat resin film, it is possible to make a radiation image sensor which can enhance the optical output of scintillator plate.

The method of making a radiation image sensor in accordance with the present invention may further comprises a step of covering the scintillator with a transparent organic film. Since at least a part of the scintillator is covered with the organic film, the present invention can make a radiation

image sensor comprising a scintillator panel which can protect the scintillator against vapor (moisture).

The transparent organic film may cover the all surfaces (top and side surfaces) of the scintillator for securely protecting the scintillator against vapor. More preferably, the transparent organic film may reach to the surface of the substrate.

The present invention will become more fully understood from the detailed description given hereinbelow and the accompanying drawings which are given by way of illustration only, and thus are not to be considered as limiting the present invention.

Further scope of applicability of the present invention will become apparent from the detailed description given hereinafter. However, it should be understood that the detailed description and specific examples, while indicating preferred embodiments of the invention, are given by way of illustration only, since various changes and modifications within the spirit and scope of the invention will become apparent to those skilled in the art from this detailed description.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a sectional view of the scintillator panel in accordance with an embodiment of the present invention;

FIG. 2 is a sectional view of the radiation image sensor in accordance with an embodiment of the present invention;

FIGS. 3A, 3B, 3C, 3D, 4A and 4B are views showing sequential steps of making the scintillator panel in accordance with an embodiment of the present invention; and

FIGS. 5A, 5B and 5C are views showing specific examples of use of the scintillator panel in accordance with an embodiment of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In the following, embodiments of the present invention will be explained with reference to FIGS. 1 to 5C. FIG. 1 is a sectional view of a scintillator panel 2 in accordance with an embodiment, whereas FIG. 2 is a sectional view of a radiation image sensor 4 in accordance with an embodiment.

As shown in FIG. 1, one surface of a substrate **10** made of Al in the scintillator panel **2** is formed with a flat resin film **12** constituted by a polyimide resin, whereas a reflecting film **14** made of Al is formed on the surface of flat resin film **12**. The surface of reflecting film **14** is formed with a scintillator **16**, having a columnar structure, for converting incident radiation into visible light. Used in the scintillator **16** is CsI doped with Tl.

The scintillator **16** formed on the reflecting film **14**, together with the substrate **10**, is covered with a first polyparaxylylene film (first transparent organic film) **18**, whereas the surface of first polyparaxylylene film **18** on the scintillator **16** side is formed with an SiO_2 film (transparent inorganic film) **20**. Further, the surface of SiO_2 film **20** and the surface of the part of first polyparaxylylene film **18** not formed with the SiO_2 film **20** on the substrate **10** side are formed with a second polyparaxylylene film (second transparent organic film) **22**, whereby all surfaces are covered with the second polyparaxylylene film **22**. As shown in FIG. 2, the radiation image sensor **4** has a structure in which an imaging device **24** is bonded to the scintillator panel **2** on the scintillator **16** side.

With reference to FIGS. 3A to 4B, steps of making the scintillator panel **2** will now be explained. First, a polyimide resin is applied by a predetermined thickness (10 μm) to one surface of a rectangular substrate **10** (having a thickness of 0.5 mm) made of Al, so as to form a flat resin film **12** (see FIG. 3A). Namely, the flat resin film **12** for flattening the rolling streaks formed upon rolling the Al sheet is formed.

After the flat resin film **12** is cured, an Al film **14**, which is a reflecting film, is formed with a thickness of 100 nm on the surface of flat resin film **12** by vacuum vapor deposition method (see FIG. 3B). Subsequently, columnar crystals of CsI doped with Tl are grown on the surface of Al film **14** by vapor deposition method, so as to form a scintillator **16** with a thickness of 200 μm (see FIG. 3C). Since CsI forming the scintillator **16** is high in moisture absorbency so that it will deliquesce by absorbing vapor in the air if left exposed, a first polyparaxylylene film **18** is formed by CVD method in order to prevent this from occurring. Namely, the substrate **10** formed with the scintillator **16** is put into a CVD apparatus, so as to form the first polyparaxylylene film **18** by a thickness of 10 μm. As a consequence, the first polyparaxylylene film **18** is formed on all surfaces of the scintillator **16** and substrate **10** (see FIG. 3D). Since the tip part of scintillator **16** is uneven, the first polyparaxylylene film **18** also acts to flatten the tip part of scintillator **16**.

Next, an Sio_2 film **20** is formed with a thickness of 200 nm by sputtering on the surface of first polyparaxylylene film **18** on the scintillator **16** side (see FIG. 4A). The SiO_2 film **20** is formed in an area covering the scintillator **16** since it is aimed at improving the moisture resistance of scintillator **16**. Since the tip part of scintillator **16** is flattened by the first polyparaxylylene film **18** as mentioned above, the SiO_2 film **20** can be made thinner (with a thickness of 100 nm to 300 nm) so that the output light quantity would not decrease.

Further, a second polyparaxylylene film **22** for preventing the SiO_2 film **20** from peeling is formed with a thickness of 10 μm by CVD method on the surface of SiO_2 film **20** and the surface of first polyparaxylylene film **18** not formed with the SiO_2 film **20** on the substrate **10** side (see FIG. 4B). When this step is completed, the making of scintillator panel **2** ends.

The radiation image sensor **4** is made when an imaging device (CCD) **24** is bonded to thus completed scintillator panel **2** on the scintillator **16** side.

With reference to FIGS. 5A to 5C, specific examples of the use of the scintillator panel **2** will now be explained. FIG. 5A is a view showing the state where the scintillator panel **2** is coupled to a flat panel sensor (a-Si thin-film transistors with photodiodes). The radio-active rays transmitted through an object **30** are converted by the scintillator panel **2** into visible lights, which are then detected by the flat panel sensor. FIG. 5B is a view showing the state where the scintillator panel **2** is directly coupled to an imaging device (CCD) **34**. The radio-active rays transmitted through the object **30** are converted by the scintillator panel **2** into visible lights, which is then detected by the imaging device **34**. FIG. 5C is a view showing the state where the scintillator panel **2** is lens-coupled. The radio-active rays transmitted through the object **30** are converted by the scintillator panel **2** into visible lights, which are then detected by a CCD camera **36**.

In the scintillator panel **2** in accordance with this embodiment, as explained in the foregoing, since the surface of substrate **10** is flattened by the flat resin film **12** made of a polyimide resin, the state of substrate surface would not influence characteristics of the scintillator panel **2**. Also, since the reflecting film **14** is disposed on the surface of flat resin film **12**, the optical output of the scintillator panel **2** can be enhanced.